"Air Quality Applications of Satellite Data"

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NOAA/NESDIS Center for Satellite Applications and Research

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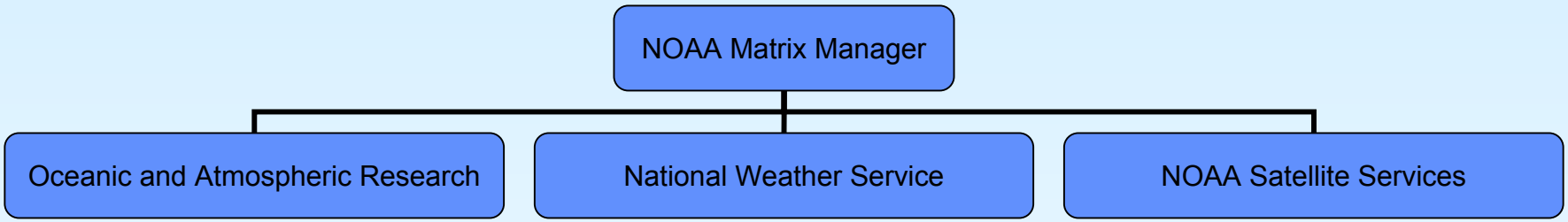
NOAA Air Quality Program Structure



Research and Development:

- Air quality model development
- Air quality assessment using field campaigns and *in situ* data

Operational air quality forecasting guidance:

- Numerical models (met and chemistry and transport)
- Forecast verification

Observational support:

- Satellite based air quality monitoring
- Air quality forecast improvements via satellite data assimilation

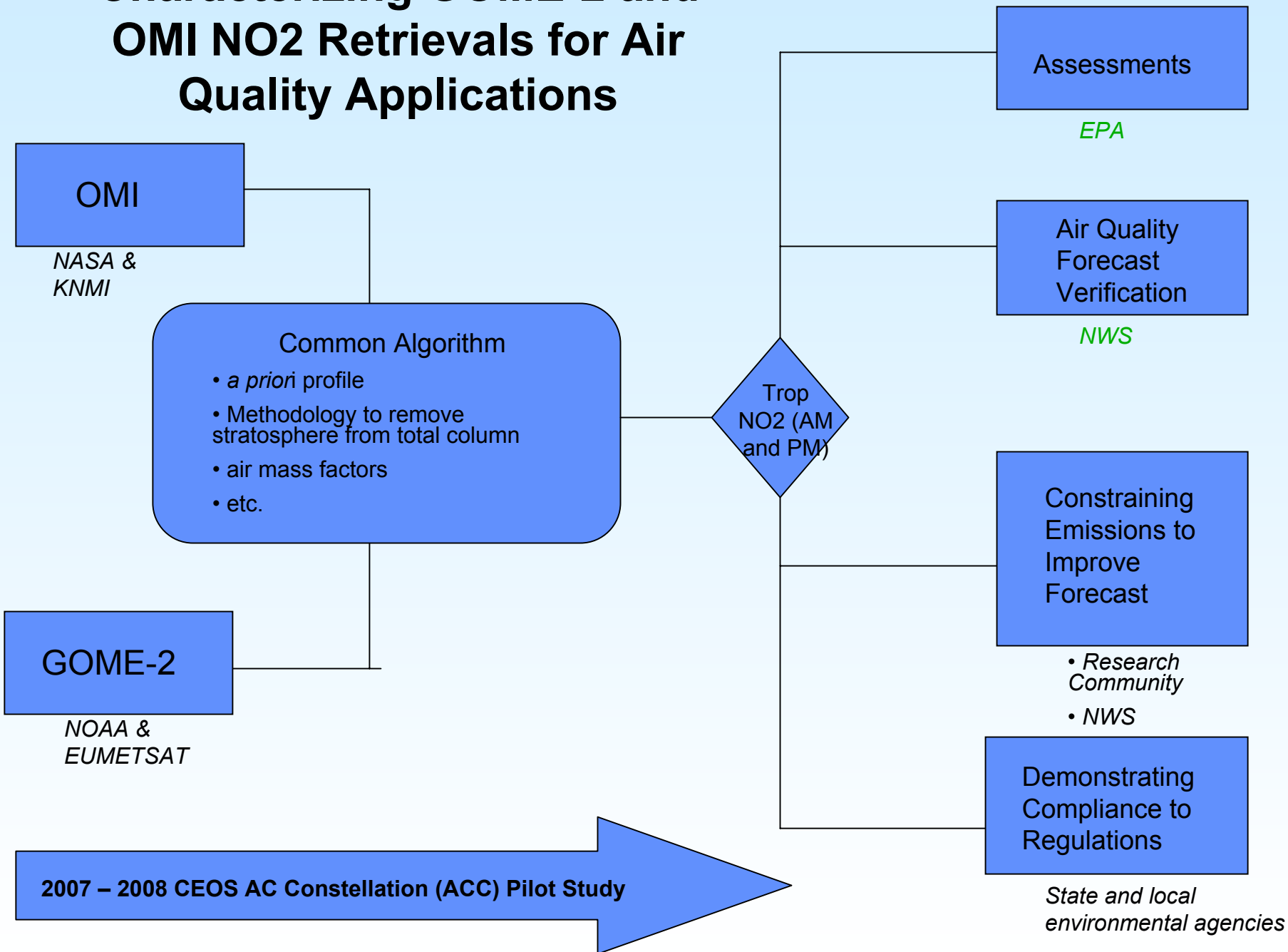
Funded by satellite services and research programs

Active collaboration with EPA for over 50 years

NESDIS Air Quality Program Objectives

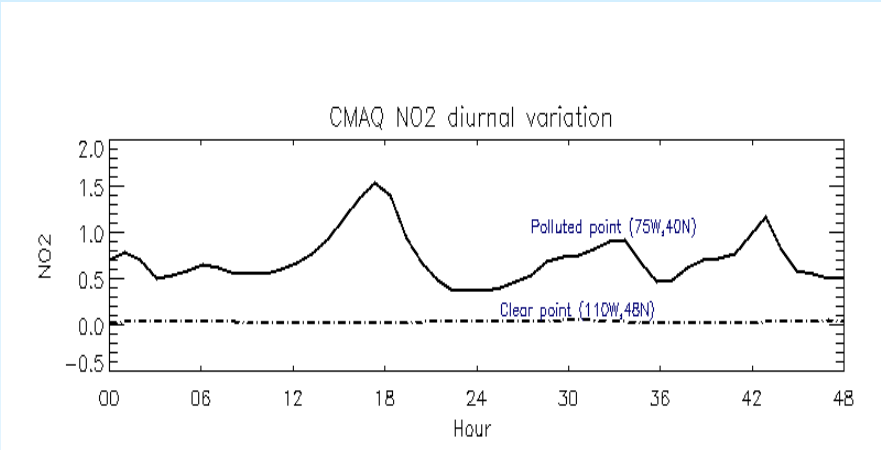
- Support NOAA-EPA MOU and MOA which includes the development and deployment of operational air quality forecast guidance
  - » Development of algorithms to derive trace gas and aerosol products from NOAA operational satellite sensors
    - – Research (NASA) to Operations (NOAA)
  - » Conduct air quality application studies to demonstrate the usability of satellite data in air quality applications
    - – Data analysis and validation
    - – Modeling and assimilation studies
  - » Support NWS in air quality forecast verification and improvements
  - » Hazard mapping system
  - » Algorithm/product development from future satellite sensors
  - » Mission planning activities
  - » Multi-agency collaborative efforts (*e.g., ACC project*)

Characterizing GOME-2 and OMI NO2 Retrievals for Air Quality Applications



ACC Project Objectives and Goals

- How to use NO_2 data from multiple satellites in improving air quality forecasts
  - » Boersma et al. (2007) showed that diurnal variations in NO_2 can be captured by processing OMI and SCIAMACHY data with a common algorithm
- Expected outcome
  - » A recommendation to National Weather service (NWS) to use satellite-derived NO_2 products to improve operational air quality forecasts
    - – Via assimilation of NO_2 to improve initial and boundary conditions
    - – Via constraining NO_x emissions using inverse modeling approaches

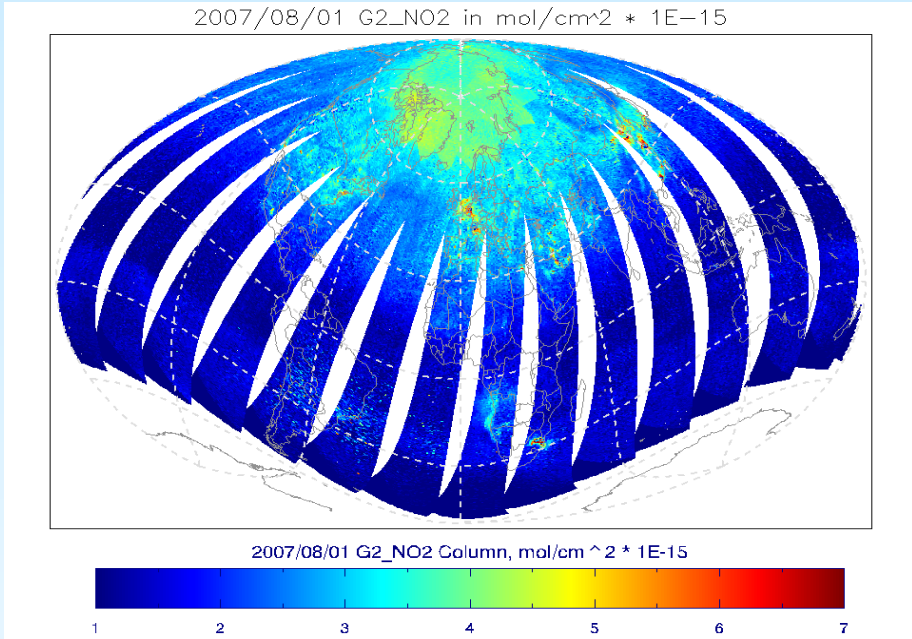


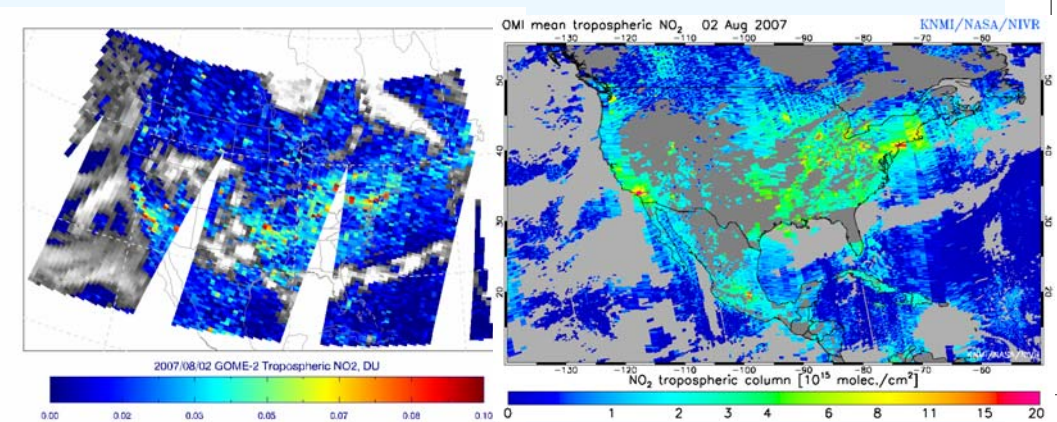
NO_2 diurnal variations:

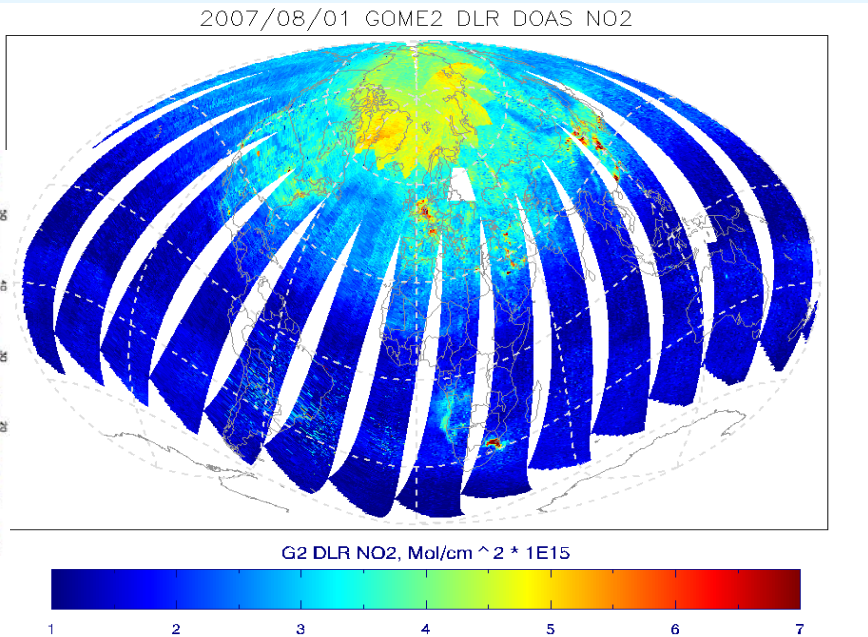
- Temporally varying sources
- Temporally varying sinks
- Physical processes
  - transport
  - dry and wet deposition

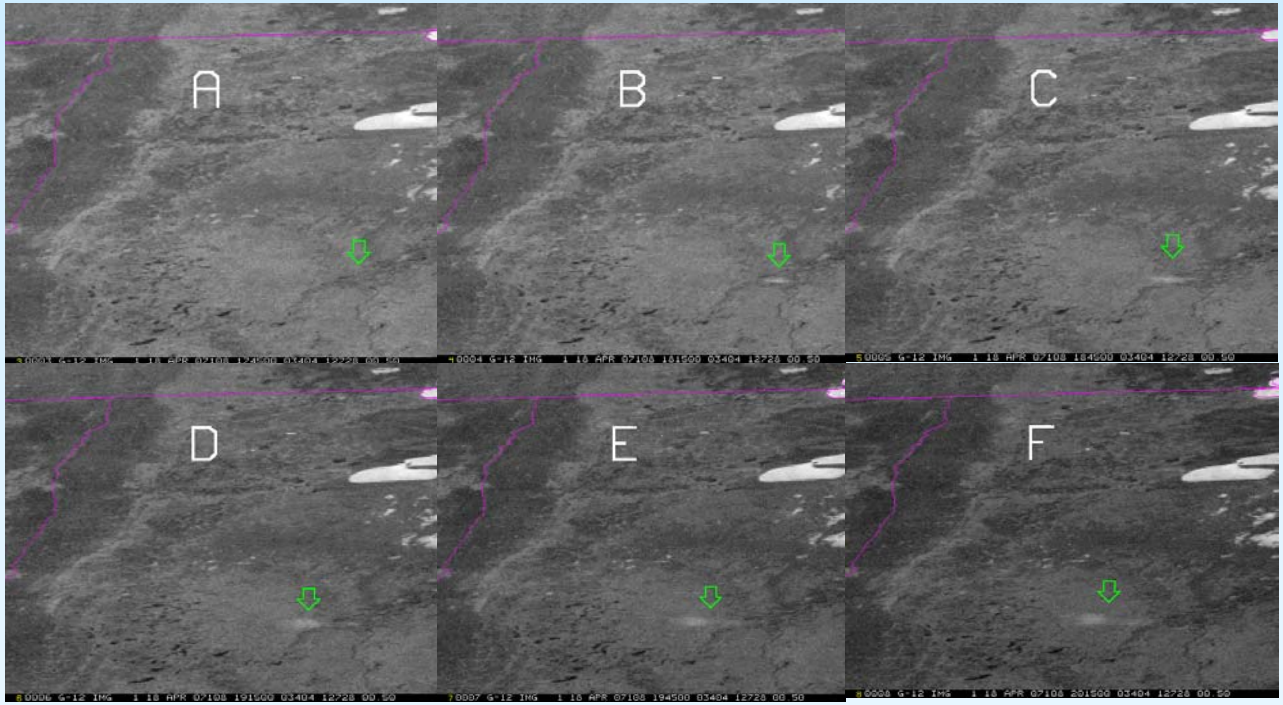
Preliminary Work

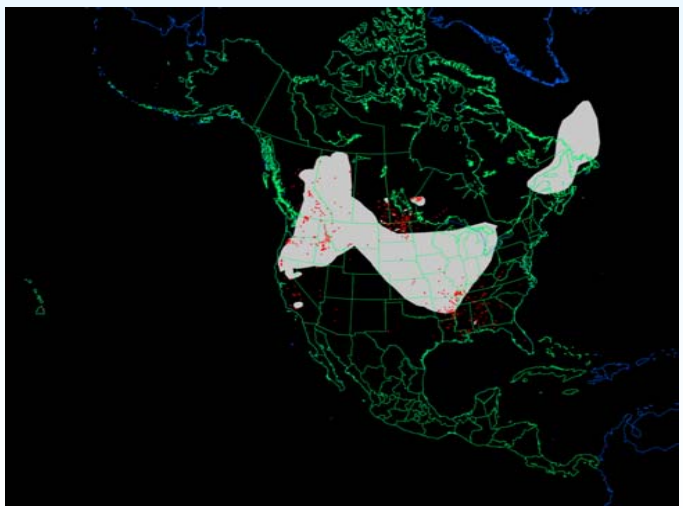
- Comparisons of NESDIS slant column NO2 with DLR NO2 show that NESDIS product is ~10% lower
  - » Differences in NO2 cross sections
  - » Differences in DOAS fitting windows
- Tropospheric NO_2 features in OMI and GOME-2 are similar but significant differences exist. Algorithm differences must be first eliminated before drawing meaningful conclusions







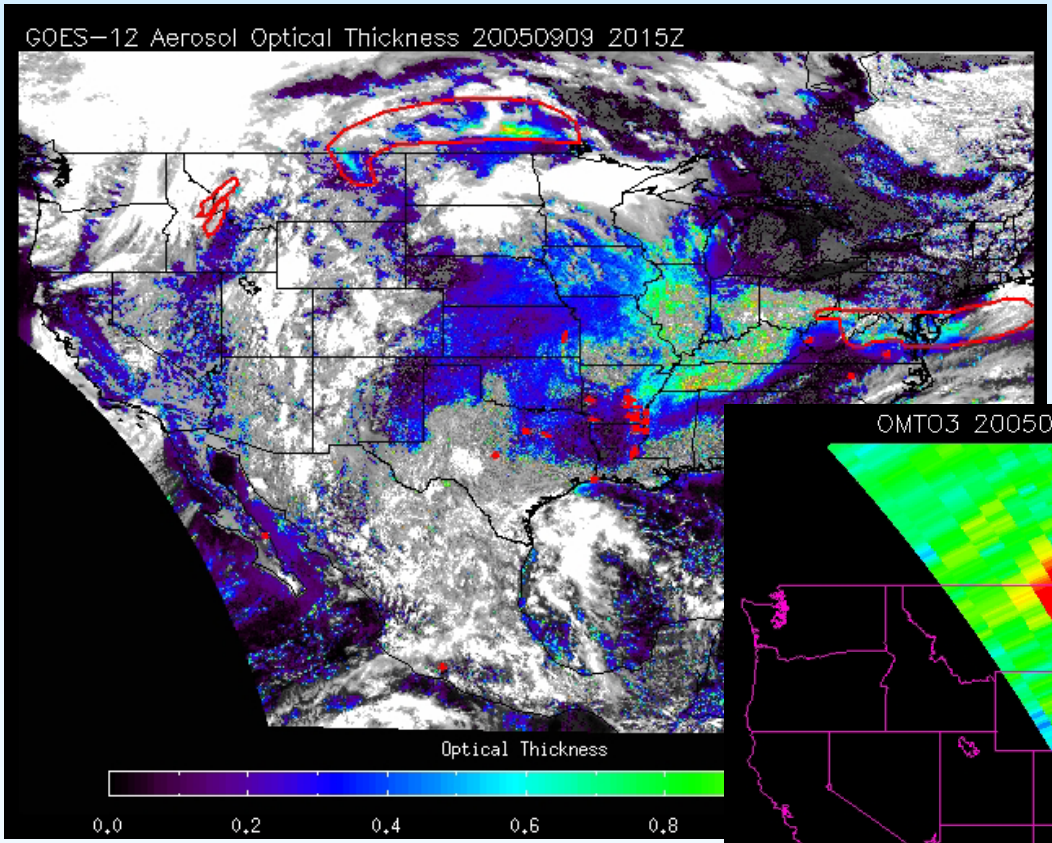


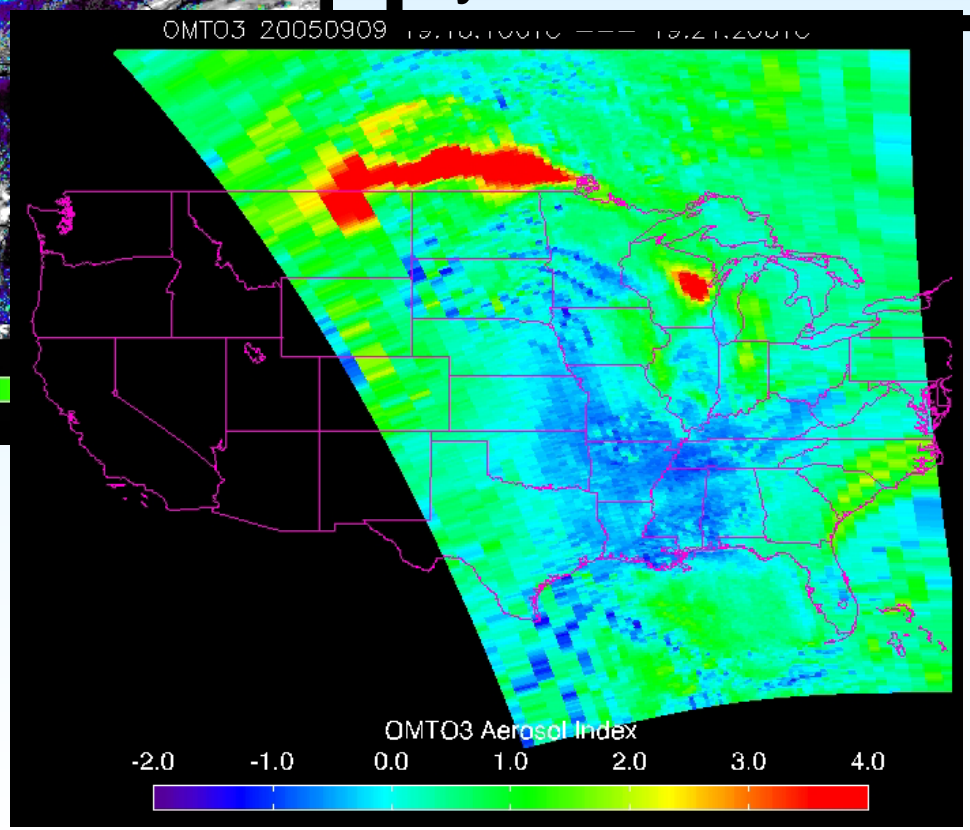


NESDIS Hazard Mapping System

- Analyst based GIS interactive tool that uses satellite visible imagery in conjunction with fire hot spots (manual and automated) to identify smoke plumes
- Difficulties: smoke mixed in or above/below clouds and smoke removed from fire source

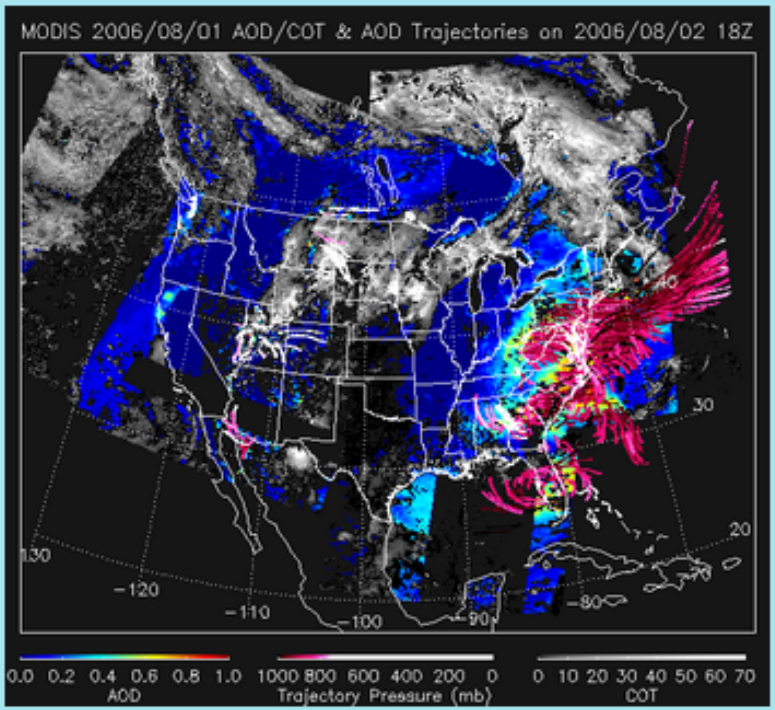
OMI sees aerosols above clouds and NESDIS plans to bring OMI Aerosol Index/optical depth images into HMS system





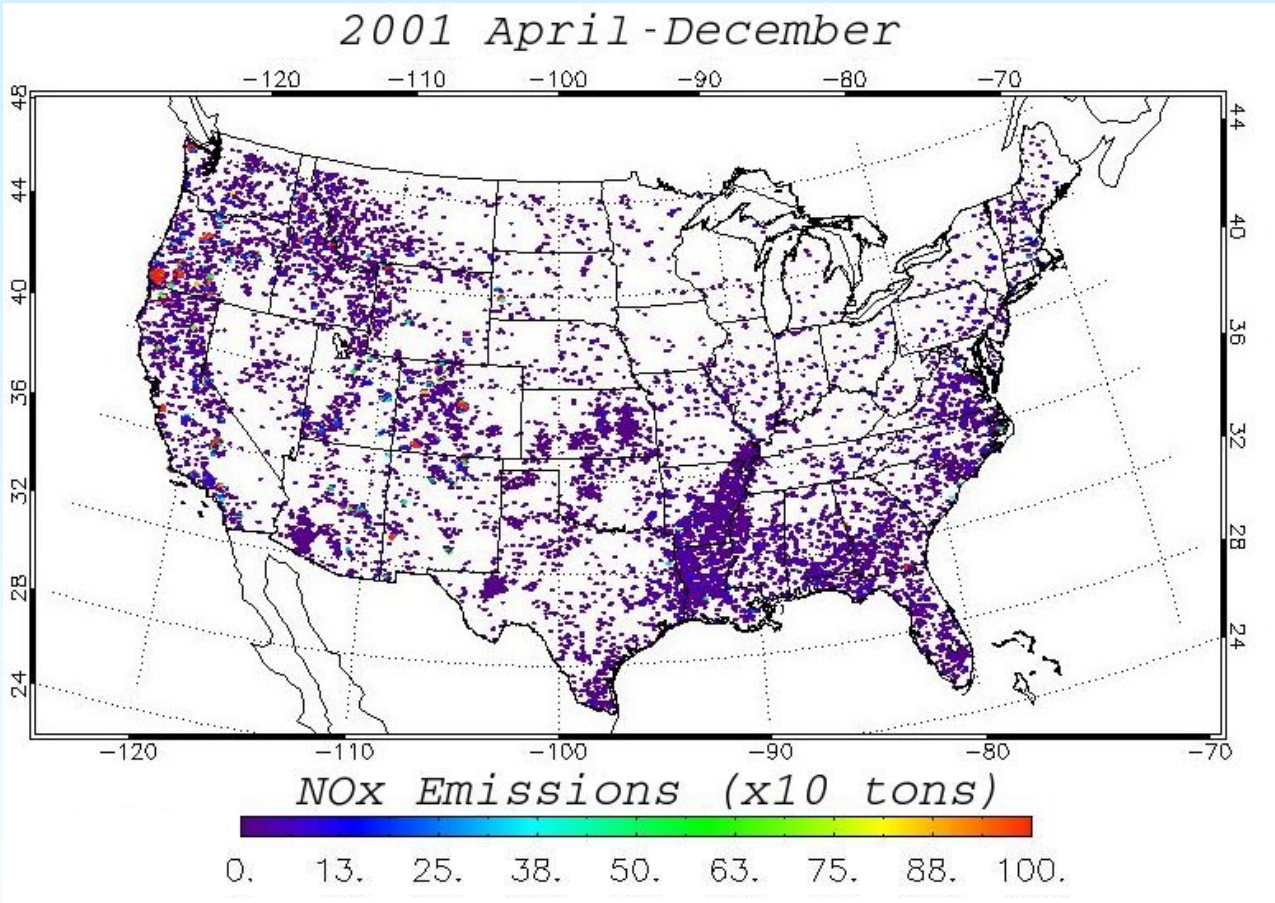
Transition of Infusing satellite Data into Environmental Applications (IDEA) into operations at NOAA

MODIS aerosol optical depth, with aerosol trajectory forecast



- One of the IDEA outputs is a 48-hr trajectory forecast of aerosols to predict surface PM2.5 concentrations. Trajectories are initialized at different pressure levels in the PBL. For forest fires with elevated smoke, these trajectories can be inaccurate. Adding OMI Aerosol Index (AI) to the system will allow us to objectively decide whether higher-altitude forecast trajectories should be initialized

Biomass Burning Emissions



OMI NO2 product can be very useful to constrain random sources of emissions in an operational air quality forecast model

Challenges

- Scales (local/regional/continental)
  - » Day to day monitoring vs spatial and temporal averaging
  - » Noisy data
- Chemical data assimilation
  - » Not just ozone assimilation?
  - » Ozone + other trace gases + aerosols
  - » Radiance assimilation or product assimilation
    - – Radiance assimilation requires fast radiative transfer model in the UV-VIS
  - » Assimilation into global models or regional models
    - – Operational global models do not have tropospheric chemistry
    - – Regional models need boundary conditions
- Future mission planning
  - » New species (e.g., ammonia)?
  - » Aerosol speciation?
  - » For aerosols, particle size?
  - » Vertical profile?
    - – Should we let satellites handle the total column and let *in situ* observations provide the verticality?

Summary

Most critical needs:

Common algorithms for processing multisensor data (e.g., NO_2)

More vertical profile information

More interaction between satellite data providers and air quality modeling community

EPA use of Satellite-derived NO_2 Product

- Improve NO_x emissions
  - » Inventories uncertain. Difficulty incorporating natural sources (biomass burning, soil, lightning)
- Understand long-range transport of NO_x
- Accountability studies
  - » Are control strategies (e.g., Clean Air Interstate Rule) working?
- Expansion of on-going projects to include GOME-2 and OMI NO_2 products
  - » Using SCIAMACHY data along with surface observed and predicted (CMAQ model) NO_2 to understand the representativeness of column NO_2 with surface NO_x emissions
  - » Differences between rural and urban area NO_x emissions
  - » Understanding retrievals from multiple sensors so trends using NO_2 data from multiple sensors can be objectively interpreted

Slide courtesy of Rob Pinder, NOAA/OAR

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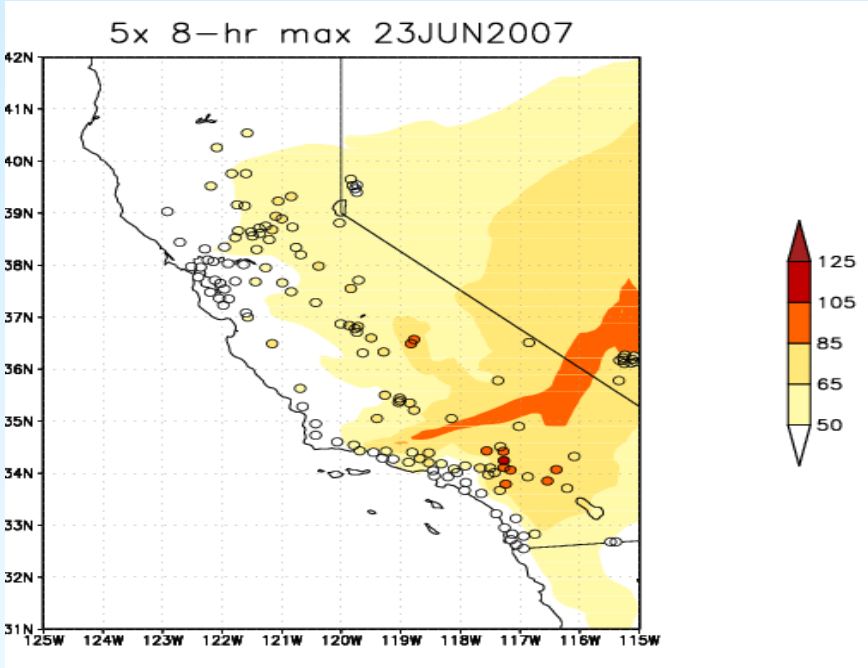
OMI and GOME-2 Applications for NCEP Air Quality Forecasting Systems

- Evaluation of WRF-CMAQ NO2 predictions over CONUS
  - » CMAQ urban area over-titration problem. Is there too much NOx in the model destroying ozone?
- Assimilation of radiances and retrievals (NO2, O3, SO2, aerosols) into NCEP Gridpoint Statistical Interpolation (GSI) variational assimilation system to account for missing sources and sinks



California Ozone Underprediction problem

Slide courtesy of Jeff McQueen, NOAA/NWS

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